Thank You, Amanda Ciccarelli, for these notes.

Video Lecture #1 – Newton's 1st and 2nd Laws & Weight versus Mass - AP Physics Version

Newton's 1st Law
when viewed from an inertial reference frame, an object at rest will remain @ rest + an object in motion will remain @ a constant velocity unless acted upon by a net external force.

inertial reference frame $a = 0$
non-inertial reference frame $a \neq 0$

mass - a measure of inertia.
inertia - tendency of an object to resist an acceleration (change in state of motion)

Newton's 2nd law: $\Sigma \vec{F} = m\vec{a}$ $N = \frac{kg \cdot m}{s^2}$
weight $\neq$ mass
(force of gravity) vector vs scalar
extrisic vs intrisic property
$\vec{F}_g = \vec{W} = m\vec{g}$ down $g = 9.8\ m/s^2$

Video Lecture #2 – Example - Three Forces act on an Object, Finding Acceleration, Mass and Velocity

EX| $\vec{F}_1 = [2.00\hat{i} + 2.00\hat{j}]$ N

$\vec{F}_2 = (-4.00\hat{i} + 3.00\hat{j})$ N

$\vec{F}_3 = (1.00\hat{i} - 3.00\hat{j})$ N

$||a|| = 1.25\ m/s^2$ $\quad v_i = (5.00\hat{i})\ m/s$

a) direction of a? $\quad$ c) v @ 15 s = ?

b) m = ?

$\Sigma\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = (2-4+1)\hat{i} + (2+3-3)\hat{j} = (-1\hat{i} + 2\hat{j})$ N

$a^2 + b^2 = c^2 \quad \Sigma F = \sqrt{2^2 + (-1)^2} = \sqrt{5}$ N

$\Sigma\vec{F} = m\vec{a} \quad \sqrt{5} = m(1.25) \quad m = 1.7889 \approx 1.79$ kg

$\sin\theta = \frac{O}{H} = \frac{\Sigma F_y}{\Sigma F} \quad \theta = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right) = 63.439° = 63.4°$ above -x axis

$v = v_i + a\Delta t \quad \vec{a} = ? \quad a = \frac{\Sigma F}{m} = \frac{-(+2)}{1.7889} \quad \vec{a} = (-0.559\hat{i} + 1.118\hat{j})$

$v(15) = 5\hat{i} + (-0.559\hat{i} + 1.118\hat{j})15 = 5\hat{i} - 8.385\hat{i} + 16.771\hat{j}$

$v(15) = (-3.39\hat{i} + 16.8\hat{j})\ m/s$

Video Lecture #3 – Newton's 3rd Law - AP Physics Version

$\vec{F}_{12} = -\vec{F}_{21}$ Newton's third law

Video Lecture #4 – Defining Normal Force and Tension

Normal Force → ⊥ to surface + a push

tension Force → rope, string. . .
in direction of rope + a pull

Video Lecture #5 – Introduction to Equilibrium

Thank You, Sarah Johnson, for these notes.

Equilibrium

$\Sigma\vec{F} = 0 = m\vec{a}$

$a = 0 = \frac{\Delta v}{\Delta t}$

It's not moving or @ constant velocity.

Video Lecture #6 – Introduction to Static and Kinetic Friction and the Coefficient of Friction

Friction:

Static (not moving) + Kinetic (in motion)

$F_f = \mu F_N$ $\quad \mu$ (mu) coefficient of friction. dimensionless

$F_{kf} = \mu_k F_N$

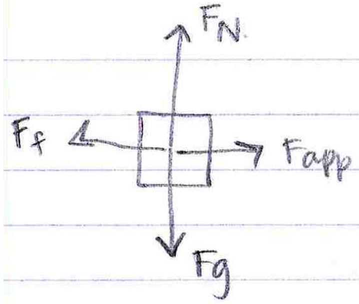
$F_{sf} \leq \mu_s F_N$

$F_{sf\,max} = \mu_s F_N$

Always opposes motion

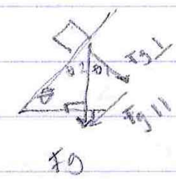
parallel to surface

independent of F_a



$\mu_s > \mu_k$

(except Teflon)



$F_{g\parallel} = F_g \sin\theta = mg\sin\theta$

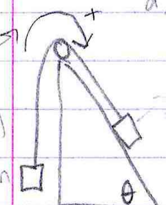
$F_{g\perp} = F_g \cos\theta = mg\cos\theta$

Video Lecture #7 & 8 – Chapter 05 #26
(Part 1) Reviewing Pulleys, Inclines and Free Body Diagrams with an Example Problem
(Part 2) Reviewing Pulleys, Inclines and Free Body Diagrams with an Example Problem

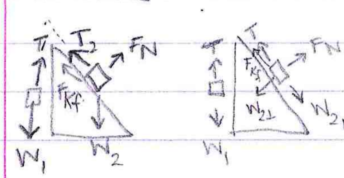
ch. 5-26) $m_1 = 2.00\,kg$ $\quad m_2 = 6.00\,kg$ $\quad \theta = 55.0^\circ$

a) $a = ?$ $\quad$ b) $T = ?$ $\quad \mu_k = 0.100$

Always identify positive direction



$T = T_1 = T_2$ (pulley is massless)



$\sum F_\parallel = -W_1 + \cancel{T} - \cancel{T} - F_{kf} + W_{2\parallel} = m a_\parallel$

on whole thing $\quad -m_1 g - \mu_k F_N + m_2 g \sin\theta = (m_1 + m_2) a_\parallel$

$\sum F_\perp = F_N - W_{2\perp} = \cancel{m_2 a_\perp} = m_2 \cos = 0$

just on m_2 $\quad F_N = W_{2\perp} = m_2 g \cos\theta$

$-m_1 g - \mu_k m_2 g \cos\theta + m_2 g \sin\theta = (m_1 + m_2) a_\parallel$

$$a_\parallel = \frac{-m_1 g - \mu_k m_2 g \cos\theta + m_2 g \sin\theta}{m_1 + m_2}$$

$$a_\parallel = \frac{-(2)(9.8) - (0.1)(6)(9.8)\cos(55) + (6)(9.8)\sin(55)}{(2) + (6)}$$

$a_\parallel = 3.1491\ m/s^2 \approx 3.15\ m/s^2$

$\sum F_\parallel = T - W_1 = m_1 a_\parallel$

on m_1 $\quad T = m_1 a_\parallel + W_1 = m_1 a_\parallel + m_1 g$

$T = m_1 (a_\parallel + g) = 2(3.1491 + 9.8)$

$T = 25.8982 \approx 25.9\ N$

Video Lecture #9 – Introduction and Review of Centripetal Force

Circular Motion:

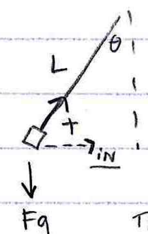
$$\underbrace{\Sigma F_{IN}}_{\text{centripetal force.}} = ma_c = m\frac{v_t^2}{r}$$

Draw FBD + ΣF_{IN}

- Not a new force.
- never is an FBD.
- IN is + (out is −)

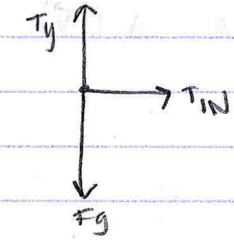
Video Lecture #10 – A Conical Pendulum - A Classic Centripetal Force Example Problem

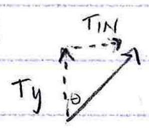
ex. Conical Pendulum.



Know $L + \theta$

find $v_t = ?$





$\sin\theta = \frac{O}{H} = \frac{T_{IN}}{T}$

$T_{IN} = T\sin\theta$

$\cos\theta = \frac{A}{H} = \frac{T_y}{T}$

$T_y = T\cos\theta$

$\Sigma F_y = T_y - F_g = ma_y = m(0) = 0$

$T_y = F_g = mg$

$\boxed{T\cos\theta = mg} \Rightarrow T = \frac{mg}{\cos\theta}$

$\Sigma F_{IN} = +T_{IN} = ma_c$

$T\sin\theta = m\frac{v_t^2}{r}$

$\sin\theta = \frac{O}{H} = \frac{r}{L}$

$r = L\sin\theta$

$rT\sin\theta = m{v_t}^2$

$v_t = \sqrt{\frac{rT\sin\theta}{m}}$

$v_t = \sqrt{\frac{L\sin\theta\, T\sin\theta}{m}} = \sqrt{\frac{L\sin^2\theta\, \cancel{m}g}{\cancel{m}\cos\theta}}$

$v_t = \sqrt{\frac{L\sin\theta\, g}{\cos\theta}}$

Video Lecture #11 – Introduction to Non-Uniform Circular Motion

Non-uniform circular motion.

Have both $\Sigma F_t + \Sigma F_{IN}$

have both $a_t + a_c$

$\Sigma F = \Sigma F_t + \Sigma F_{IN}$

Video Lecture #12 – Introduction to Resistive Forces or the Force of Drag

6.4 Resistive Forces

Force of Drag $\propto$ (proportional) to Velocity

$\vec{R} = -b\vec{v}$ (b ⇒ proportionally constant kg/s)

(small objects @ small speeds)

$R = \frac{1}{2} D \rho A v^2$ (more generally applicable)

D ⇒ Drag Coefficient. (no dim)

ρ ⇒ Density of medium

A ⇒ cross sectional area ($A \perp \vec{v}$)

$\vec{v}$ = velocity of object

Video Lecture #13 – Deriving the Equation for Terminal Velocity

ex. object in ~~freefall~~ Air, falling

$\Sigma F_y = R - F_g = ma_y$

$\frac{1}{2} D\rho A v^2 - mg = ma_y$

$a_y = \frac{D\rho A v^2}{2m} - g$

w/ no resistance force

$a_y = -g$

as $v\uparrow \Rightarrow R\uparrow \Rightarrow a \Rightarrow 0$

$a = 0 \Rightarrow$ $v = v_{terminal} = v_t$

$(R = F_g)$

NOT UAM

$0 = \frac{D\rho A v^2}{2m} - g$

$g = \frac{D\rho A v^2}{2m}$ $\boxed{v_t = \sqrt{\frac{2mg}{D\rho A}}}$ terminal velocity

Video Lecture #14 – Numerical Modeling - An Example Freefall Problem with Air Drag

Numerical Analysis

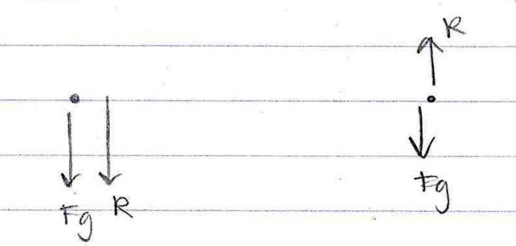
ex. Baseball   Throw ball upward @ 50.0 m/s.

$m = 145\ g$

$r = 3.7\ cm.$ up $\Sigma F_y = -R - F_g = ma_y$

$D = 0.284$ down $\Sigma F_y = R - F_g = ma_y.$

up   down



Video Lecture #16 – Chapter 06 #35 - An Introductory Drag Force Problem

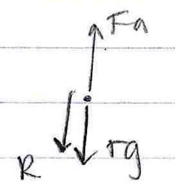
Ch. 6-35

copper ball $r = 2.00\ cm.$ $b = 0.95\ kg/s$

constant speed $V = 0.090\ m/s$ $R = \mp bv$ direction.

$D = 8.92 \times 10^3$

fluid.



$\Sigma F_y = F_a - R - F_g = ma_y$

$F_a - (+bv) - mg = m(0) = 0$

$F_a = mg + bv$

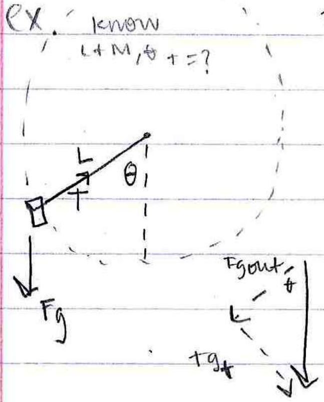
$F_a = (0.2989)(9.81) + (0.95)(0.09)$

$D = \frac{m}{V} \Rightarrow m = DV_{sphere} = D\frac{4}{3}\pi r^3$ $F_a = 3.014\ N \approx \boxed{3.01\ N}$

$m = (8920)\left(\frac{4}{3}\pi(0.02)^3\right) = 0.2989\ kg.$

Video Lecture #16 – Example Problem - A Stopper on a String moving in a Vertical Circle

ex. know L+M, θ T=?



Tension is in the "in" direction.

$\sin\theta = \frac{O}{H} = \frac{F_{g_t}}{F_g}$ $F_{g_t} = mg\sin\theta$

$\cos\theta = \frac{A}{H} = \frac{F_{g\,out}}{F_g}$ $F_{g\,out} = mg\cos\theta$

$\Sigma F_t = F_{g_t} = ma_t$

$\cancel{m}g\sin\theta = \cancel{m}a_t$

$g\sin\theta = a_t$

min v_t to keep in circle

@ top .... $\theta = 180°$

$0 = mg\cos 180 + \frac{mv_t^2}{L}$

$\cancel{m}g = \frac{\cancel{m}v_t^2}{L}$ $\boxed{v_t = \sqrt{gL}}$

$\Sigma F_{in} = T - F_{g\,out} = ma_c$

$T - mg\cos\theta = m\frac{v_t^2}{r} = \frac{mv_t^2}{L}$

$$\boxed{T = mg\cos\theta + \frac{mv_t^2}{L}}$$

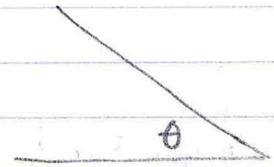
Video Lecture #17 – Chapter 05-06 Review

Review Ch. 05 + Ch. 06.

Equilibrium

$\Sigma \vec{F} = 0 = m\vec{a} \Rightarrow \vec{a} = 0$

@ c.v. or not moving.



$\Sigma F_{\perp} + \Sigma F_{\parallel}$

F.B.D $\Rightarrow \Sigma F$

identify • + $\underline{\text{dir}}$ (Pulley)

• object(s)

• which Direction.

$F_{kf} = \mu_k F_N$

$F_s \leq \mu_s F_N$

$\left(F_{sf_{(max)}} = \mu_s F_N\right)$

When can you ΣF on multiple objects?

$\underset{whole}{\Sigma F} = m_t \underset{\uparrow \text{same.}}{a}$

Circular motion

$\Sigma F_{IN} = m a_c = \frac{m v_t^2}{r}$

• not a new Force.

• never draw in FBD

• in is + (out is −)

* Note: $a_t \neq 0$ $a_c + a_t$

$\vec{R} = -b\vec{v}$ $R = \frac{1}{2} D \rho A v^2$

$V_{terminal} \Rightarrow$